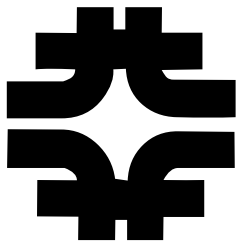
On M. I. to TeV Injection : Bunch Lengths and transfer efficiencies. Store 2150 – 2155.



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Fermilab

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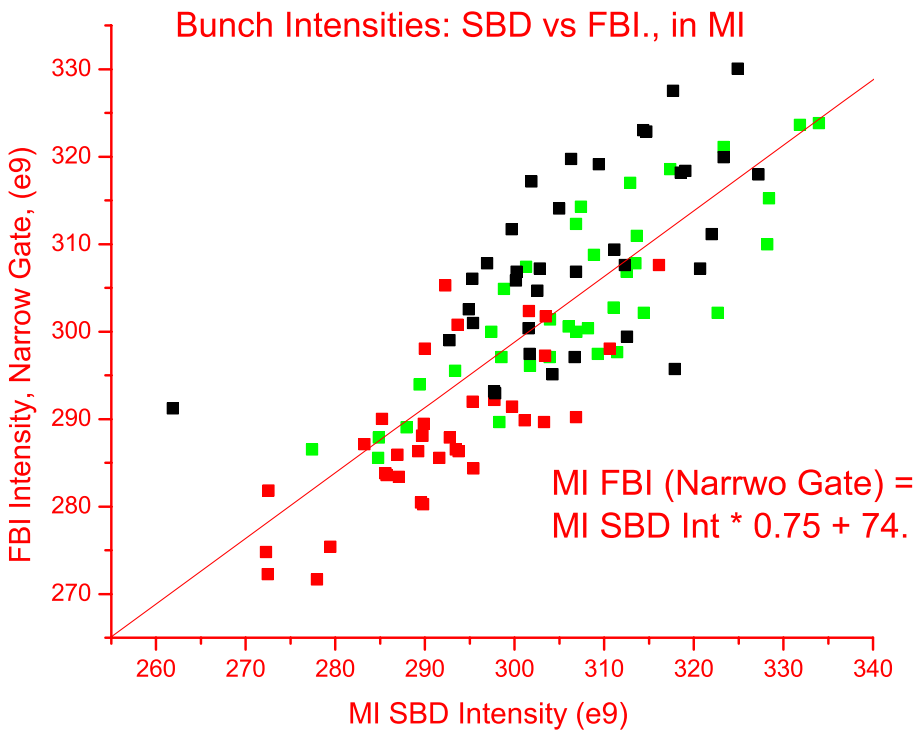
Commissioned by Mike Church and Jean Slaughter:

- For stores 2150, 2153, and 2155 determine the magnitude of the
- * longitudinal emittance blowup during MI-->Tev proton and antiproton
- * transfers. Use T:SBDPWS[i] (i= Set #) from the 36 Sets of the Inject
- * Protons Case for the proton Dt in the Tevatron and use I:SBD04S[40] from
- * the 36 Sets of the Inject Protons Case for the proton Dt in the MI. Use
- * T:SBDAWS[j1(i),j2(i),j3(i),j4(i)] from the 9 Sets of the Inject
- * Antiprotons Case (where the j's are picked appropriately -- see MDC SDA
- * intensity device summary for correct mapping) for the 4 antiproton Dt's
- * in the Tevatron and use I:SBD04S[14,35,56,77] from the 9 Sets of the
- * Inject Antiprotons Case for the 4 antiproton Dt's in the MI. Use the
- * MDC equations (see note on Tev emittances for stores 2070 and 2155) to
- * calculate Dp/p and longitudinal emittance. Plot Dt(MI) vs Dt(Tev),
- * Dp/p(MI) vs Dp/p(Tev), and L_emit(MI) vs L_emit(Tev). Look for
- * correlations with intensity, injection number, etc.
- *

Code Status

- Starting from OSDAPhysics Java Package. Use the TeVSBDdata and MISBDdata classes, written by Nikolai Kouropatkine.
- Wrote a class, to be soon committed in OSDA Physics, which creates a small data sheet, from which the following plots have been made. Such this study can be repeated on other stores " easily", if we keep maintaining OSDAPhysics.
- (Nikolai: I had to make a small modification in TeVSBdata: we want to compute the $\delta p/p$ from the width instead of sigma, let us discuss this.. It is just a 2-line change.)
- Ran the code for Proton only (see late why)
- Making plots:
- Cost of such a study: ~ 2 hours of Java, ~ 3 hours of study/making plots, ~ 1 to 2 hours of writing things up..

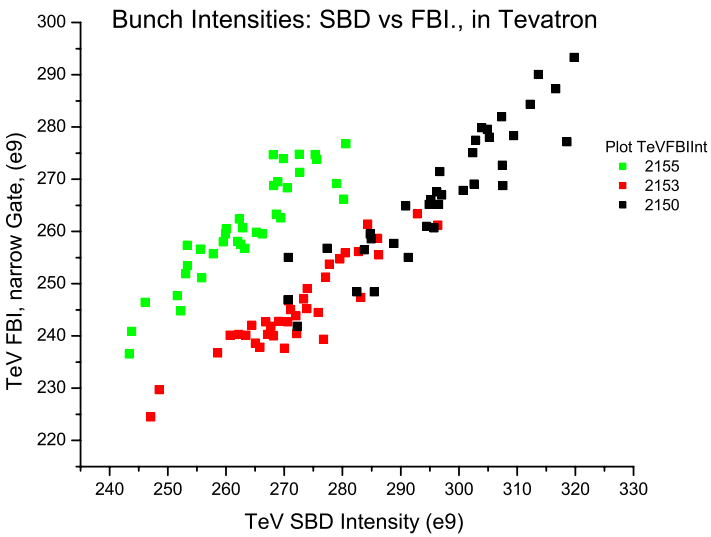
Bunch Intensity: FBI or SBD ?

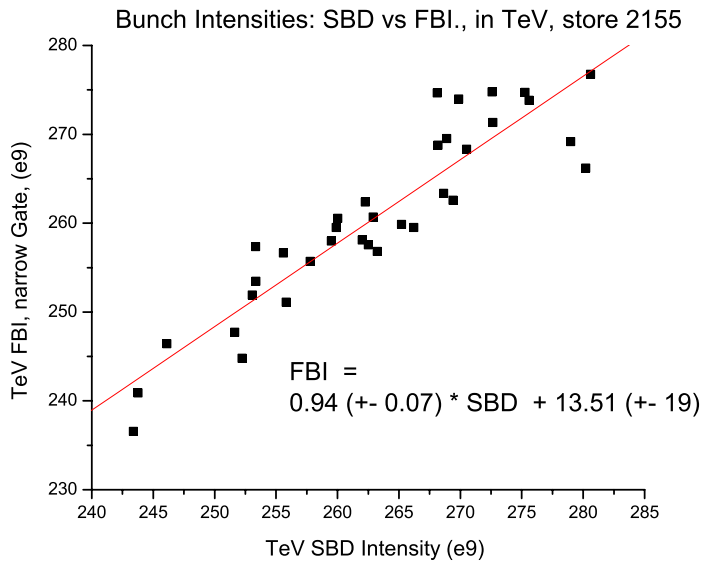


There are many reason to believe that the intensity returned by the SBD is more accurate than the "narrow" gate, especially for pbar.

However, the SBD software has been recently upgrade, and (may be?) the bunch intensity returned by this front – end is the process of recalibration. In any event, here is correlation plot.

Bunch Intensity: FBI vs SBD in TeV, Protons





- TeV Bunch intensity relative calibration looks pretty good <R> = 0.99, rms is 1.5%, for store 2155.

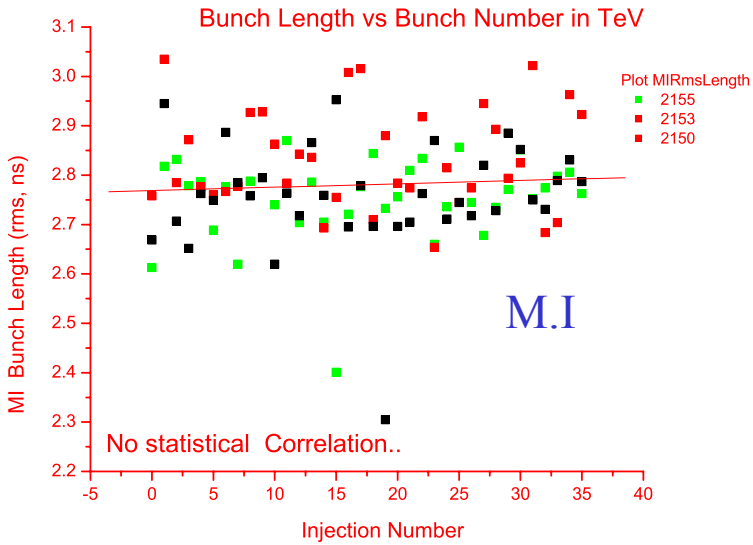
Notes on Relative Calibrations..

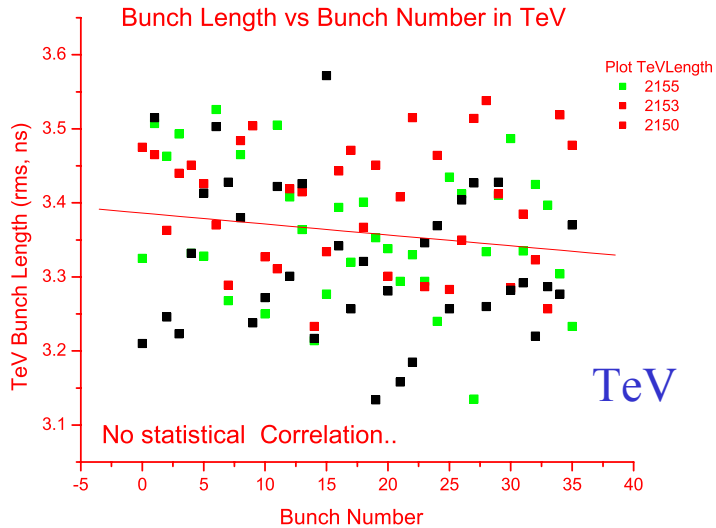
Store 2155 is O.K., but store 2150 and 2153 were “mis-calibrated”. Bob Flora worked on the TeV SBD software, on Jan 10 2003. Store 2155 was taken a day later. Store 2153 ramped-up on Jan 10 at 3:51 A.M. So the date of this re-calibration do match the discrepancy between these 3 stores. The note from Bob Flora in the instrument log-book says:

The SBD intensity calibration was changed on 03/01/10 Friday at 17:30.
New Calibration: Physical Constants
Protonic Charge = 1.602189246E-19 Coulomb
Wall Monitor = 1.288 Ohm
Attenuation Ratios
First Splitter = 3
Second Splitter = 2
Fudge Factor = 1.148 --> was changed to --> 1.047
The old fudge factor still remains a mystery, but the new value was chosen to reflect Alvin's estimates of the cable's dispersive tail "leakage".

The amplitude of the change (10%) does match what is shown on the previous lot
However, Tom meyer also placed a one line note stating that he is finished with TeV FBI work, and he will describe what he has done at a later date in the TeV log book. I lost the trail on that one. ...The procedure he followed is documented, though (BeamDocs # 410)

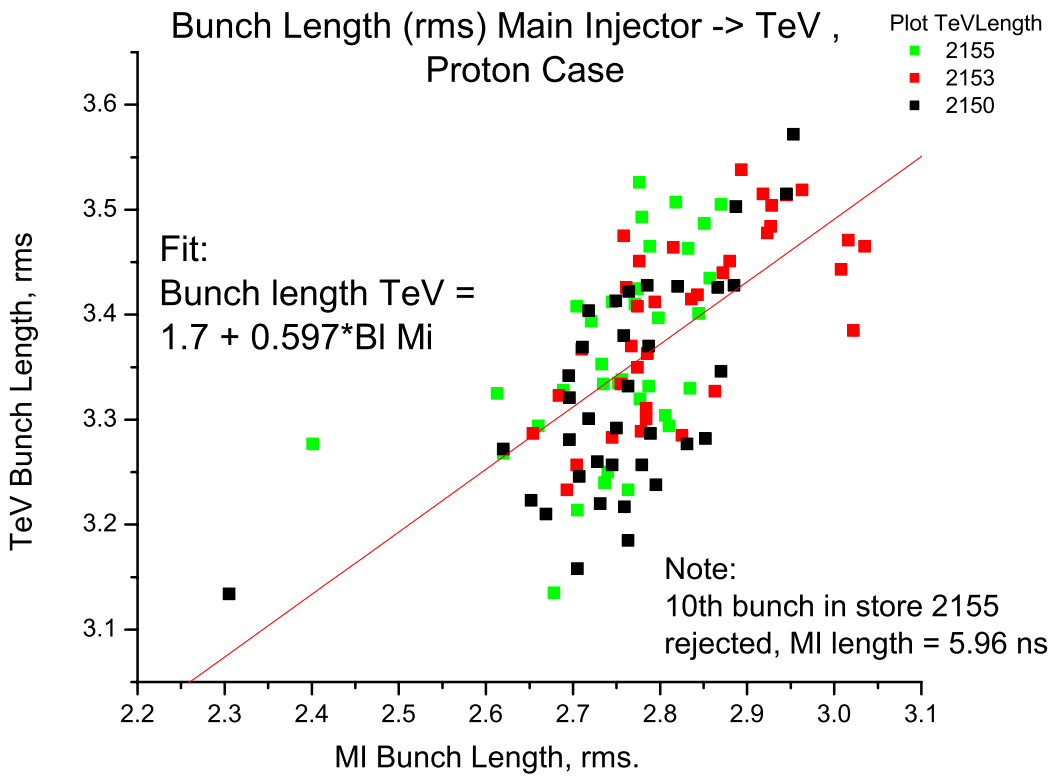
Bunch Length rms (width, not σ!) vs Bunch Number





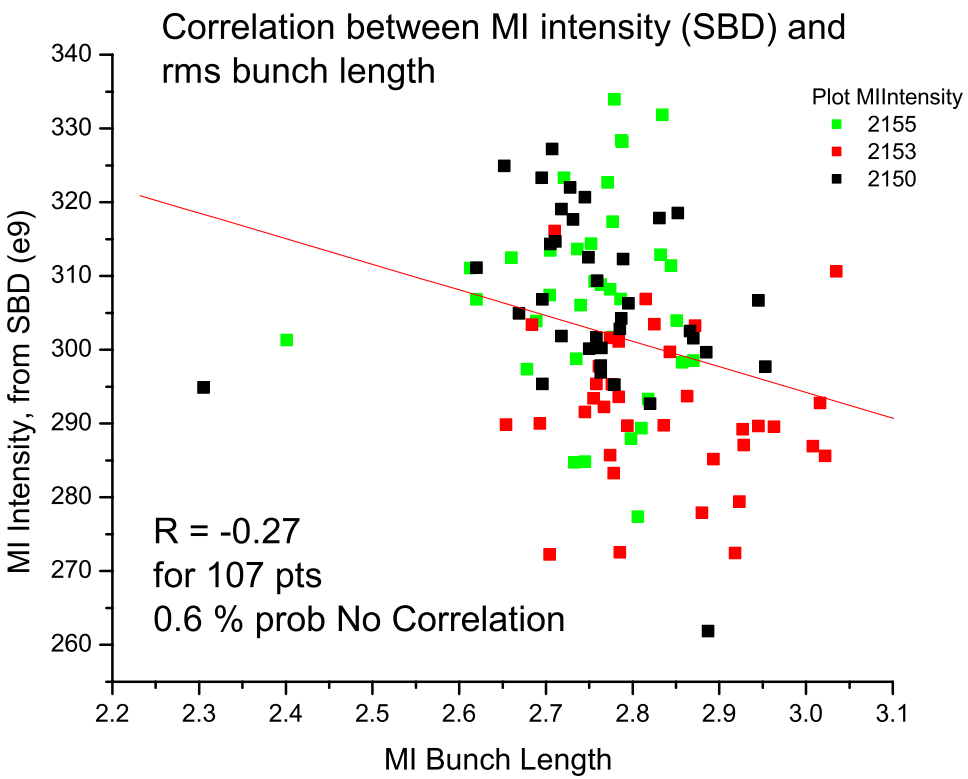
No Correlation with injection number.. The feed-forward loop making correction seems to have little effect, longitudinally at least. The relative rms of the rm widths for the TeV SBD is 2.9 %

Bunch Length rms, TeV vs MI



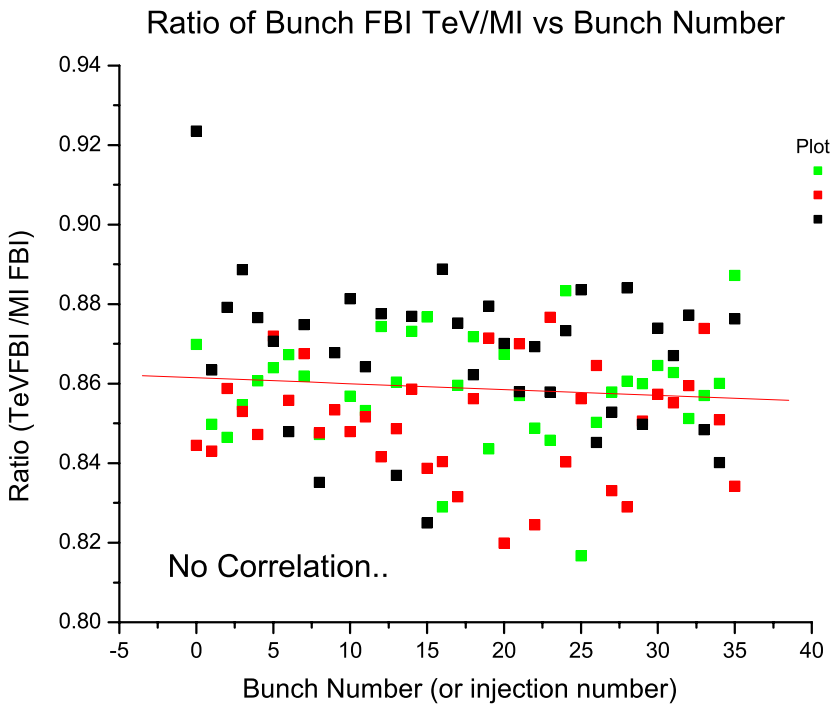
This time, we see a clear correlation, at least, between the bunch length measured in MI and TeV. However, there is blow-up factor of 21%, in average, (rms of 4%) .

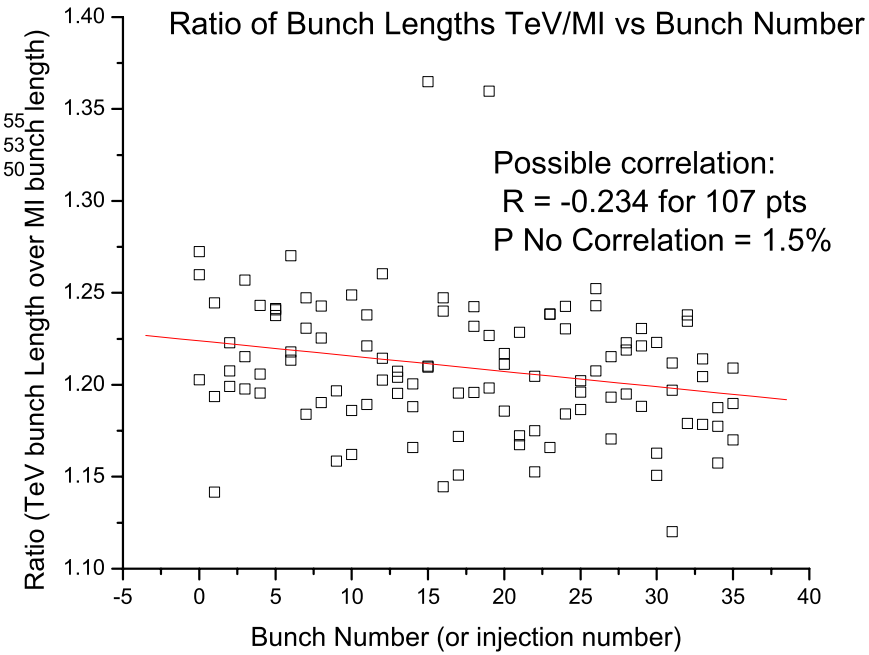
Bunch Length rms, vs Intensity in MI



The sign of this correlation (almost real by statistical standard) is surprising: long bunches tend to be of smaller intensity.

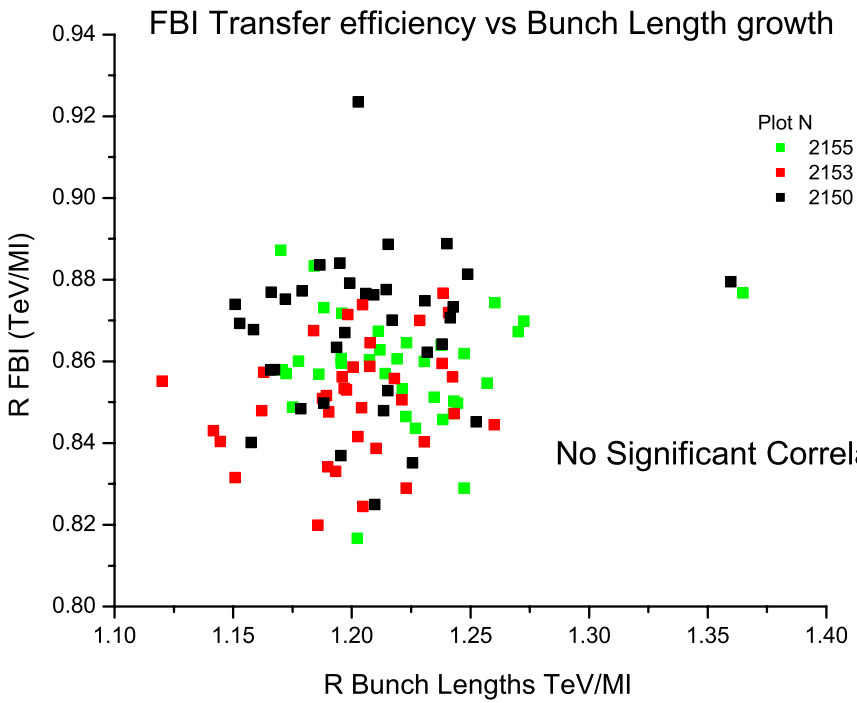
Bunch Length growth and transfer efficiencies…

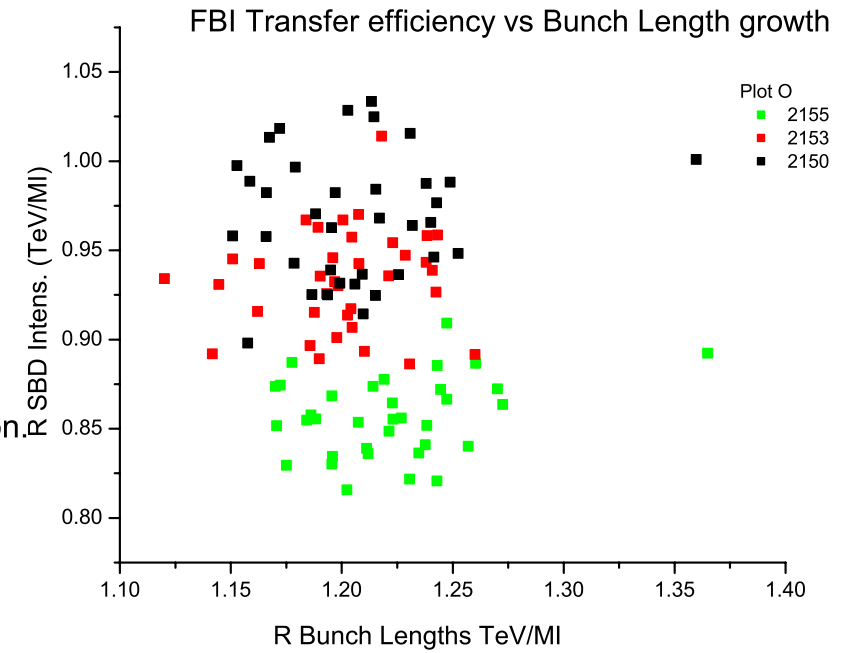




- No strong correlation with bunch number, again..

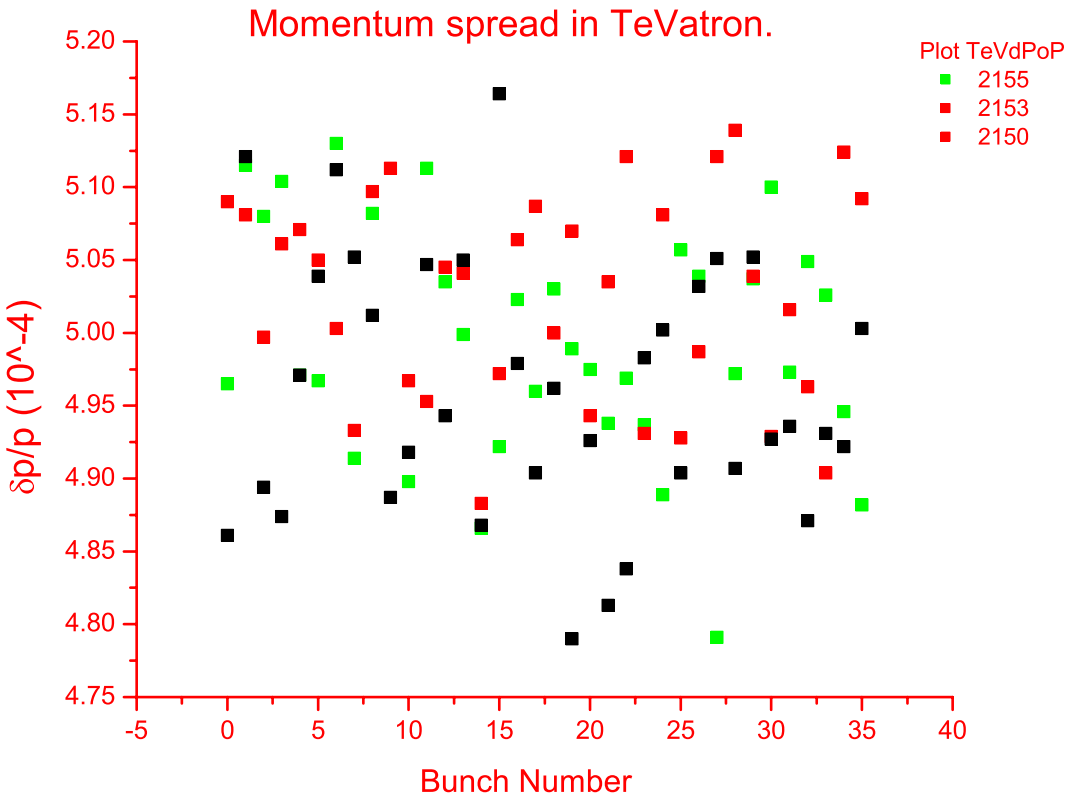
Bunch Length growth and transfer efficiency, II





- Disappointing and a bit mysterious: no correlation between transfer efficiency and emittance dilution ..

Momentum Spread in TeV

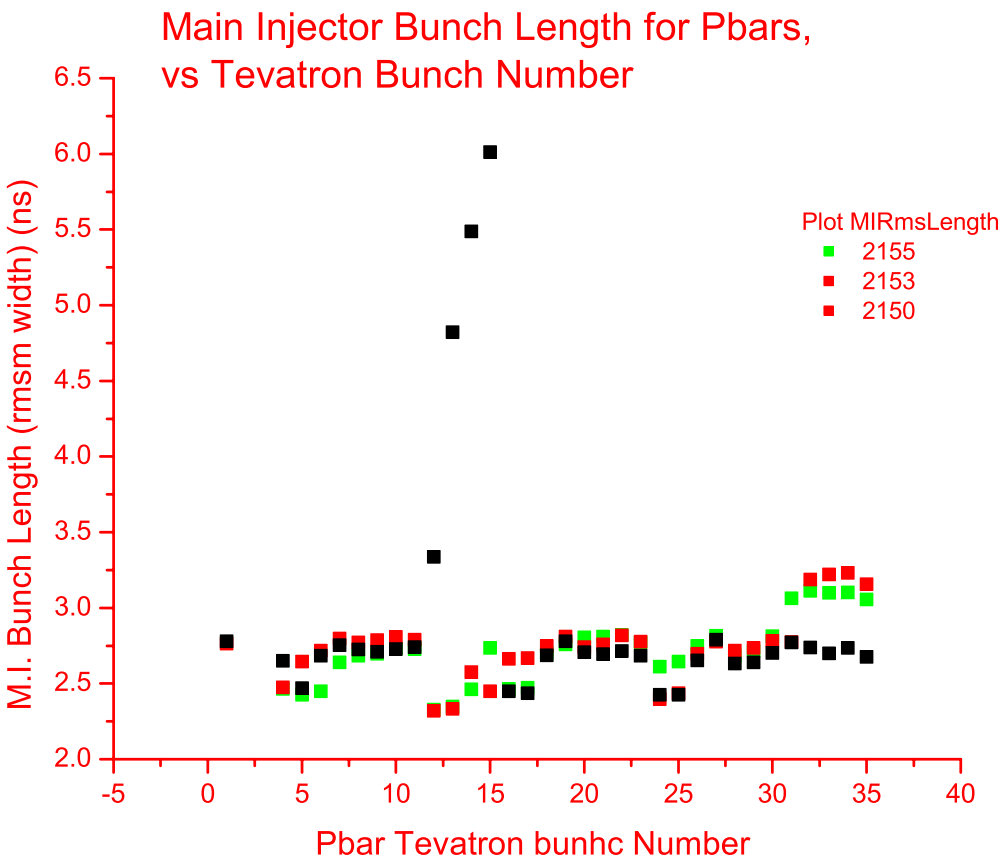


<dp/P> = 4.99 $10^{-4,}$ relative r.m.s = 1.6%

The momentum spread calculation for the Tev., at 150 has been recently revisited. (Mike Church formulas..)

The MI Java class – possibly the SBD front-end - still uses the "linear" bucket area formulas, valid only at small emittance. So the comparison MI-TeV is a bit unfair.

Antiprotons..



M.I data only ! Tevatron data is missing (D.A. errors, or 0. !)

Strong dependency on pbar transfer number, as anticipated.

One transfer for store 2150 went south….

Status…

OSDA Physics software is becoming available => improve the speed and correctness of such analysis in the future.

The data for pbar in case “Inject Pbars” is either missing or suspicious. In addition, for store 2155 at least, the pbar FBI reported D.A. errors.

The proton data is interesting. We unfortunately have an apparent bunch lengthening of 21% going from M.I. -> TeV.

Is this emittance dilution real?

- rms calculation: consistent truncation between SBD and MI algorithms?
- If not, then, why and when this bunch broadening occurs?

May be this is expected : although TeV and M.I. r.f. bucket are matched (same area in long phase space), the different voltages lead to different bunch length for a given, conserved emittance ? Then, let us compute M.I./TeV emittance “the same way” !!!

Real emittance dilution due to injection energy or r.f. phase errors (most likely explanation ?)